GPCS451

Good Practice Case Study

Savings from the control of steam distribution pressure

University of Leeds

CARBON TRUST

Making business sense of climate change

When steam pressure is reduced in a distribution system, the saturation (condensing) temperature of the steam is lowered and heat losses from conduction, convection and radiation are less. At sites with significant variations in steam demand, reducing the distribution pressure, and regulating it in line with demand and ambient temperature, can lead to significant energy and carbon savings. At the University of Leeds, the benefits resulting from greater control of steam pressure include:

- **Annual cost savings of over £4,000**
- **Annual energy savings of over 330MWh**
- **Carbon savings of over 16 tonnes/year**
- **Payback period of 2.5 years.**

University of Leeds

The University of Leeds is one of the largest universities in the UK with over 31,500 students. The main campus is situated next to the city centre and covers 39ha (96 acres). It includes some of the early University buildings as well as modern multi-storey departmental buildings and a full range of administrative and functional buildings including a library, art galley, concert hall, union building, refectory, conference facilities dining rooms, gymnasium, student flats and a hall of residence.

Introduction

Steam is supplied to the University campus and the adjacent teaching hospital from a central combined heat and power (CHP) generating station complex known as Leeds GSC. A steam link between this facility and the University was commissioned in 1995 and meant that the University's ageing boilerhouse, which was becoming increasingly expensive to maintain and operate, could be shut down. The Leeds GSC has a total generating capacity of 18MWe, comprising five reciprocating engines (2.2–3.3MWe), a 5.0MWe gas turbine and a 700kWe steam turbine generating set.

The University uses about 85,000 tonnes/year of steam; the average demand is 4 tonnes/hour in summer and 16 tonnes/hour in winter, with peaks of up to 25 tonnes/hour. The contractual arrangement between the University and its energy supplier uses a complex formula to derive energy charges. Excluding fixed costs, the continuous supply of steam costs the University around £800,000/year.

Installation of pressure reducing valve

Leeds GSC supplies steam to the University's steam distribution network and the hospital buildings at a pressure of 700-800kPa(g) (7-8 bar(g)). Most of the steam is condensed in calorifiers or plate heat exchangers in individual buildings to provide heat to circulating hot-water, space-heating systems and for domestic hot water. There is also a small demand for process steam.

The steam supply to the University campus and the return condensate piping run in underground service ducts. To reduce the steam distribution energy losses, a pneumatic pressure-reducing valve (PRV) (see Figure 1) was installed to reduce and control the distribution pressure to between 250 and 400kPa(g) (2.5 and 4.0 bar(g)) in response to demand (season and time of day) and ambient temperature. The annual mean pressure is approximately 320kPa(g) (3.2 bar(g)). There is further local pressure regulation down to 170kPa(g) (1.7 bar(g)) before the calorifiers.

The piping runs are shown superimposed on the campus map in Figure 2, which also shows the Leeds GSC and the location of the PRV. There are over 1,700 metres of steam distribution piping

***Figure 1** Pressure reducing valve*

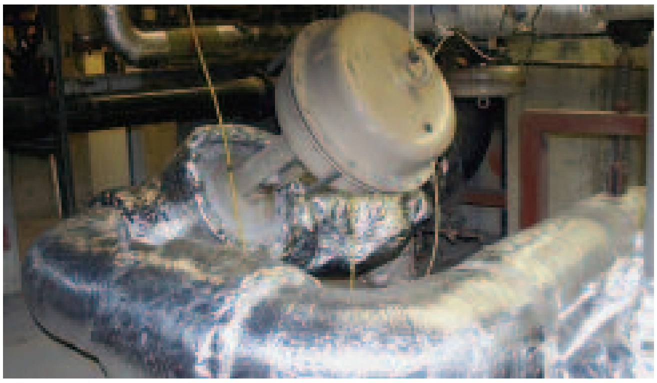
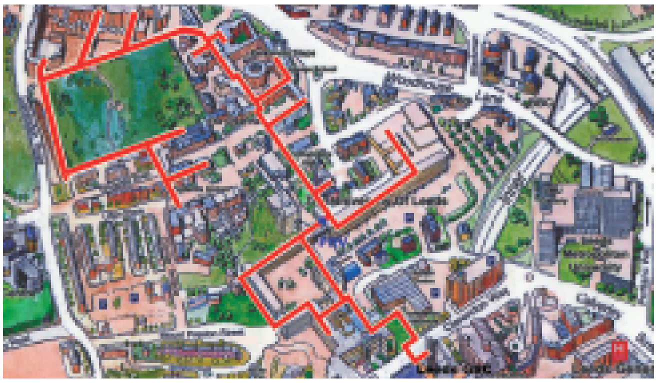


Figure 2 *Campus map showing steam distribution system*



downstream of the PRV, consisting of 230mm (10 inch), 200mm (8 inch) and 150mm (6 inch) nominal bore steel piping, which is insulated to a high standard.

Control of steam pressure

The operation of the PRV is controlled through the University's Building Management System (BMS), which is programmed to regulate the steam distribution pressure as a function of:

- Season
- Time of day
- Ambient temperature.

Figure 3 shows an example of winter operation (October–April). From midnight to 4am, the steam pressure is set to 400kPa(g) (4bar(g)). Between 4am and 7pm, the valve modulates between 400 and 300kPa(g) (4 and 3 bar(g)) (hatched area) in response to changes in ambient temperature between 3°C and 10°C. The pressure set points are 400kPa(g) (4 bar(g)) for temperatures below 3°C and 300kPa(g) (3 bar(g)) for those above 10°C. Figure 4 shows actual operating data over a seven-day period of winter operation when ambient temperature rarely exceeded the lower modulating threshold (3°C). In this example, the steam distribution pressure was controlled predominantly by the time-of-day settings of the controller. Ambient temperature-related modulation occurred only during the last four days.

Figure 3 *Winter operation of steam distribution system*

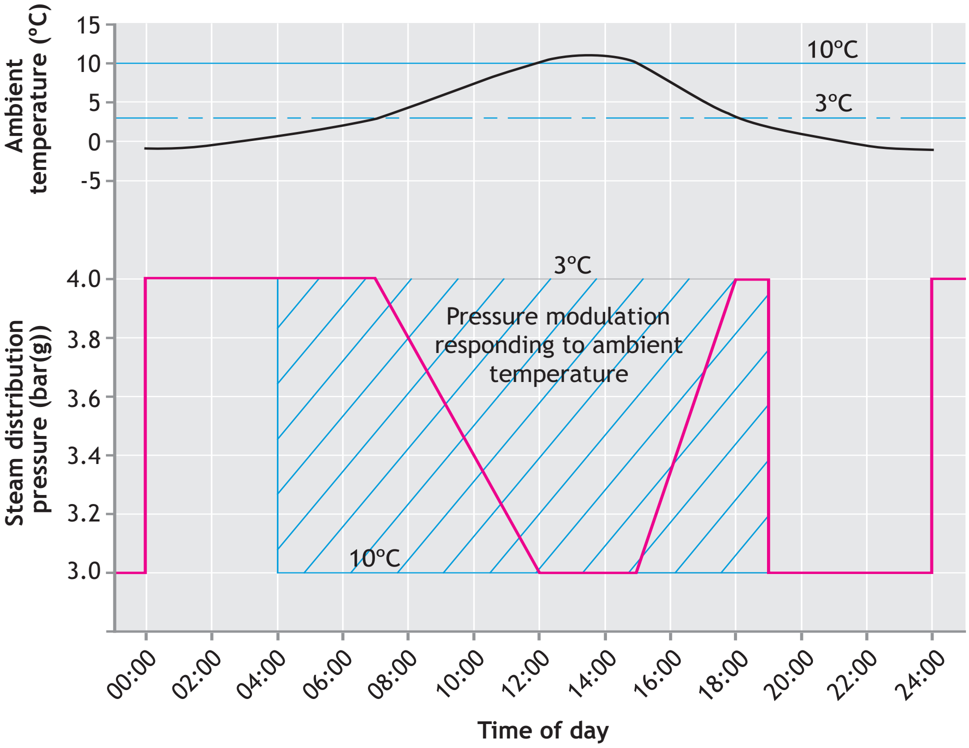
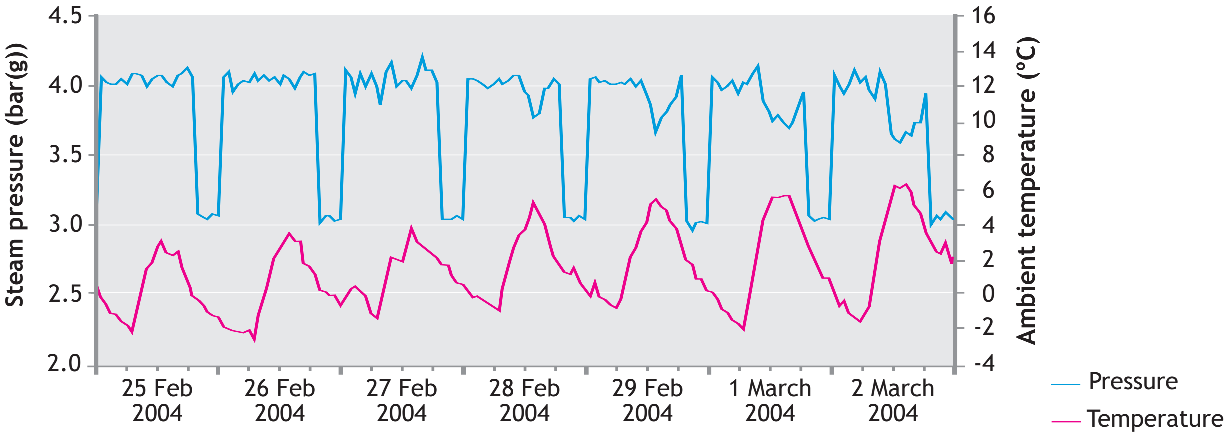


Figure 4 *Steam pressure modulation — cold winter period*



Energy and cost savings

Installation of the PRV and automatic regulation of the steam distribution pressure by the BMS has reduced heat losses from the steam distribution pipework and thus reduced boiler fuel consumption. This has resulted in cost savings to the University, as less steam is required from the Leeds GSC. Annual savings are summarised in Table 1.

The reduction in heat losses shown in Table 1 is obtained from the difference between (1) the heat loss at the steam temperature of 145°C obtained with the average modulated steam pressure of 320kPa(g) (3.2 bar(g)) and (2) that at the higher steam temperature (170°C) corresponding to a pressure of 700kPa(g) (7 bar(g)). The calculation is based on the actual length of the three sizes of pipe, an average (measured) insulation surface temperature of 38°C in the main service duct and an average ambient temperature of around 31°C in the service ducts.

Table 1 *Annual savings*

	Value
Reduction in steam distribution heat losses	258MWh/year
Equivalent saving in boiler fuel[1]	331MWh/year
Reduction in steam imported from Leeds GSC	430 tonnes/year
Reduction in emissions of carbon to atmosphere	16.2 tonnes/year
Cost of installing pressure reducing valve[2]	£10,000
Steam cost saving to the University[3]	£4,085/year
Simple payback period	2.5 years

[1] Assuming 80% marginal gross boiler efficiency and 10% condensate heat losses.
[2] 2004 prices.
[3] Based on a marginal cost of £9.50/tonne for steam. It takes account of the variable costs of fuel, make-up water and water treatment.

The annual energy and carbon savings are based on 8,760 hours operation of the steam system. Of the overall energy savings, some 75% are attributable to the basic reduction in steam pressure to around 300kPa(g) (3 bar(g)) and 25% to the time and ambient temperature-based modulation between 400 and 250kPa(g) (4 and 2.5 bar(g)).

Other benefits resulting from the operation of the steam system at a reduced pressure (e.g. less frequent failure of steam traps and fewer steam leaks) have not been quantified.

Economics at other sites

For a site operating its own boilerhouse, the payback period for installing a PRV will depend primarily on the fuel price. The potential energy savings will be site-specific and depend on the extent of the steam distribution network, steam pressures, the exposure of the steam piping and the quality of its insulation. In cases where steam demand is less variable, the use of a simple governing valve to give a fixed downstream pressure may be the most cost-effective solution.

"With total annual energy costs of about £5 million, we are keen to do whatever we can to make efficiency improvements. In addition, the University's leading role in teaching and research in environmental issues makes us conscious of our wider responsibilities to the environment and anything we can do to reduce carbon emissions is considered beneficial.

Although the operation of the pressure relief valve has a relatively small impact on our overall energy costs, its installation represents a relatively low-cost improvement with an attractive return that results in a significant energy saving and environmental benefit."

Mike Barron, Mechanical Services Manager, University of Leeds

The project results have been independently verified on behalf of the Carbon Trust.

The pressure-reducing valve was supplied by:
Samson Controls (London) Ltd
Redhill, Surrey
RH1 2NL
Tel: 01737 766391

The energy management system was supplied by:
Trend Control Systems Ltd
PO Box 34
Horsham, West Sussex
RH12 2YF
Tel: 01403 211888

The centralised CHP plant is owned and operated by:
Dalkia Utilities Services plc
Elizabeth House
56-60 Staines Road
Staines, Middlesex
TW18 4BQ
Tel: 01784 496200

There may be other suppliers of similar services and energy efficiency equipment in the market. Please consult your supply directories, call the Carbon Trust Energy Helpline on 0800 58 57 94, or contact a relevant trade association.

Tax incentives

The Enhanced Capital Allowance (ECA) scheme allows businesses to deduct 100% of capital expenditure on energy efficient equipment. The Energy Technology List was set up to identify those products qualifying for ECA tax relief. It currently features over 5,000 products, including boilers and associated equipment, and continues to grow on a monthly basis. For further information about the Energy Technology List and ECAs, visit **www.eca.gov.uk** or call the helpline on 0800 58 57 94.

Publications from the Carbon Trust

A range of free publications is available including:

GPG382 *Energy efficient operation of heat distribution systems*

ECG066 *Steam generation costs*

ECG092 *Steam distribution costs*

For details of the Carbon Trust's services and free publications, call the helpline on 0800 58 57 94 or visit the website (**www.thecarbontrust.co.uk/energy**).

Tel 0800 58 57 94
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The Carbon Trust works with business and the public sector to cut carbon emissions and capture the commercial potential of low carbon technologies.

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